Using Risk Assessment to Justify Higher Level Controls

Kansas Safety and Health Conference

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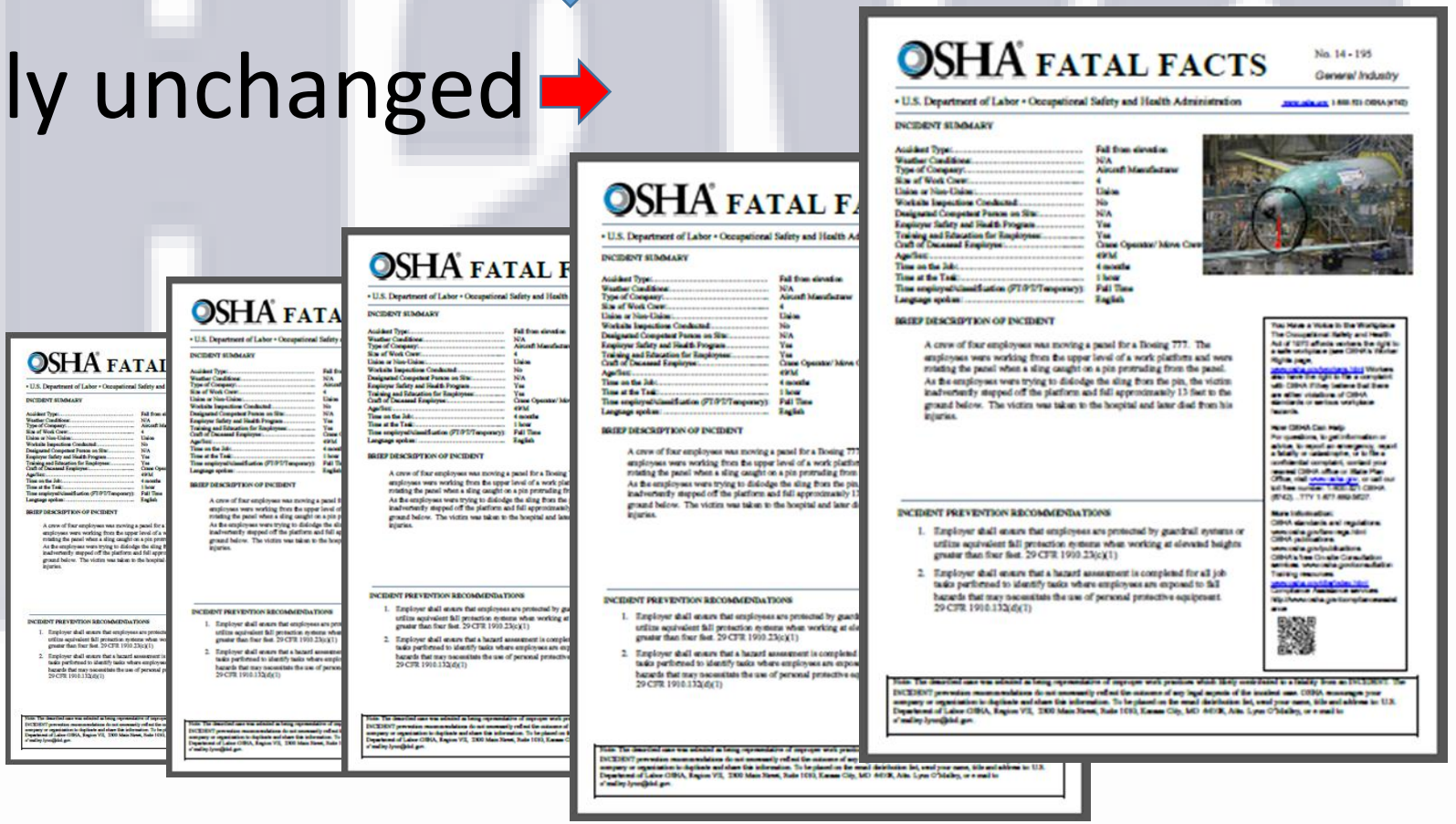
Hays

Risk Assessment

1. *The Need for Assessing Risk*
2. *Risk Assessment Process*
3. *Selecting Tools*
4. *Selecting 'Higher Level' Controls*

Fatalities and Serious Incidents (FSI)

- Incident rates have declined
- FSI rates basically unchanged



Fatalities and Serious Incidents (FSI) Continue to Occur

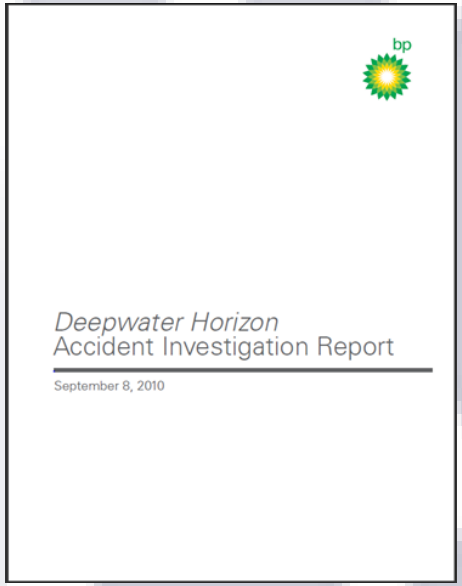
- Major Disasters
- Fires and Explosions
- Chemical Releases
- FSIs in Construction, Energy, Agriculture, Transportation, among other industries

Suggested sources: NIOSH FACE Reports http://www.cdc.gov/niosh/face/inhouse.html
CSB Videos: http://www.csb.gov/videos/

The Need for Assessing Risk

Deepwater Horizon
Accident Investigation Report

September 8, 2010



"A *formal risk assessment* might have enabled the BP Macondo well team to identify further mitigation option to address risks…" p. 36

Key Standards

- *ISO 31000 - ANSI/ASSE Z690-2011 Risk Management Standards*
- *ANSI/ASSE Z590.3-2011 Prevention through Design*
- *ANSI B11.0-2015 Safety of Machinery*
- *MIL-STD-882E-2012*

Safety Management Systems requiring Risk Assessment

- *OSHA's VPP*
- *ANSI Z10*
- *BS OHSAS 18001*
- *ILO-OSH 2001*
- *ISO 14001*
- *ISO 45001*

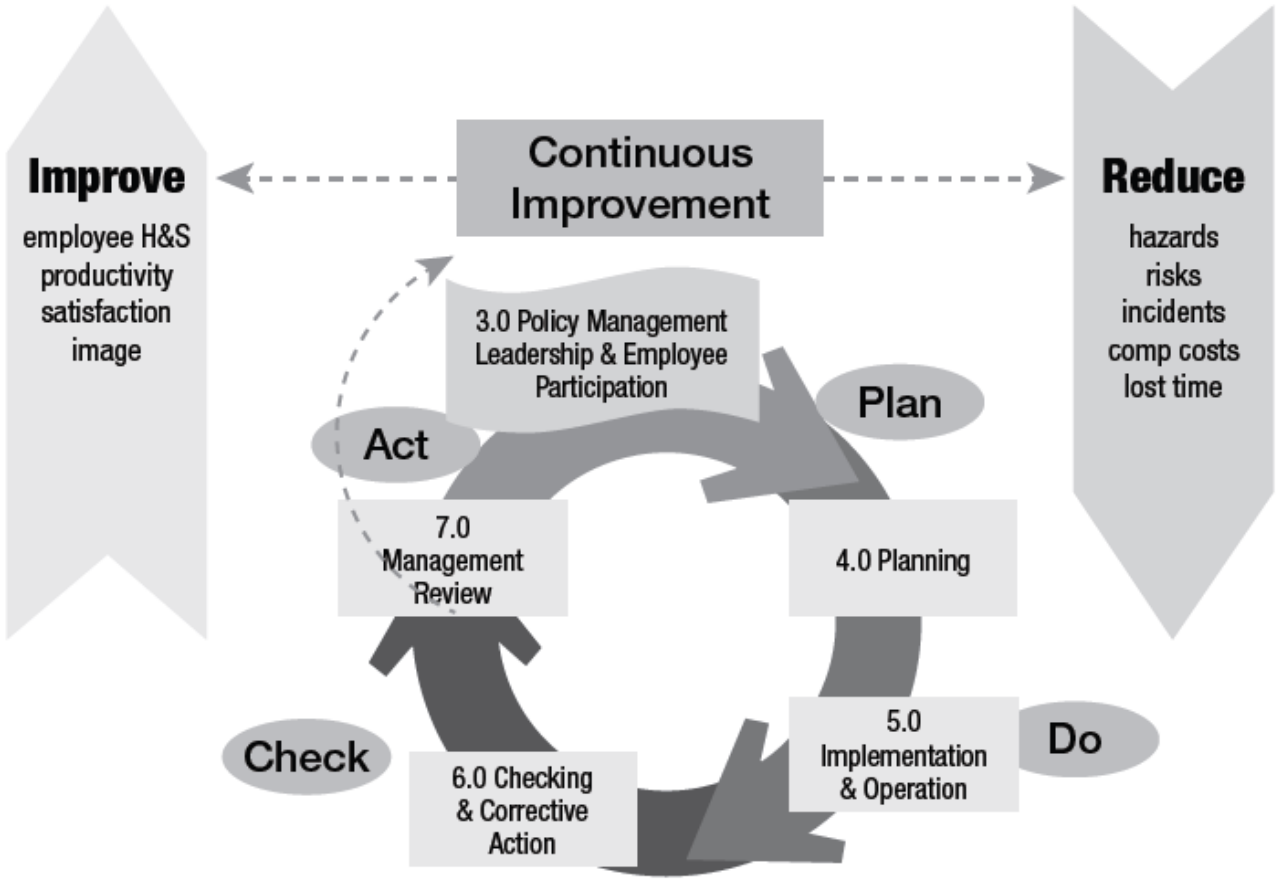


Figure 2-OHSMS Cycle

The Rising Importance of Risk Assessment

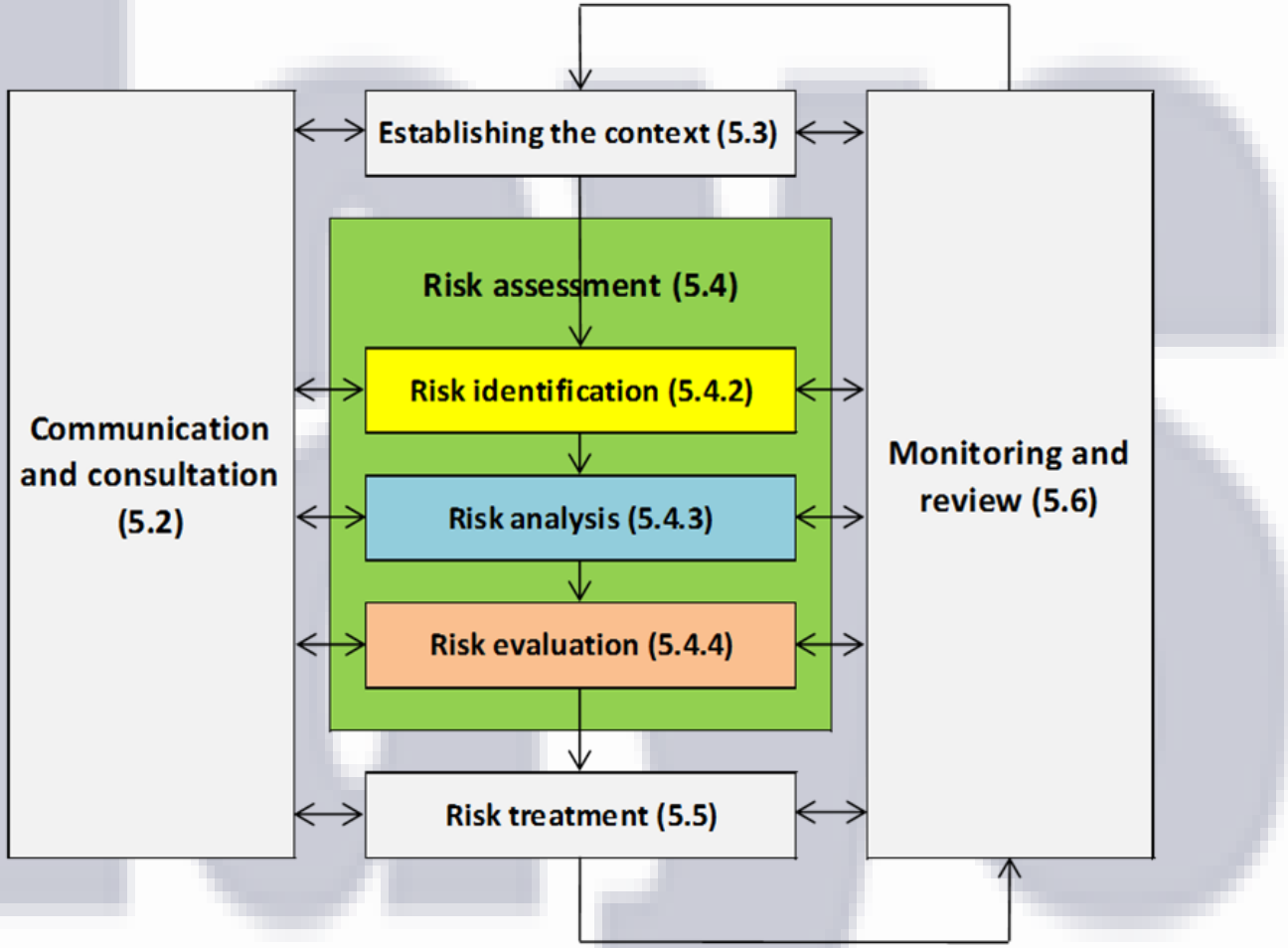
American Society of Safety Engineers
Risk Assessment Institute

- Established February 2013
- Risk-based information, tools, and research for safety professionals
- Risk Assessment Certificate Program

http://www.oshrisk.org/

Risk Assessment

1. *Identify Hazards/Risks*
2. *Analyze Risk*
3. *Evaluate Risk*
4. *Treat Risk*



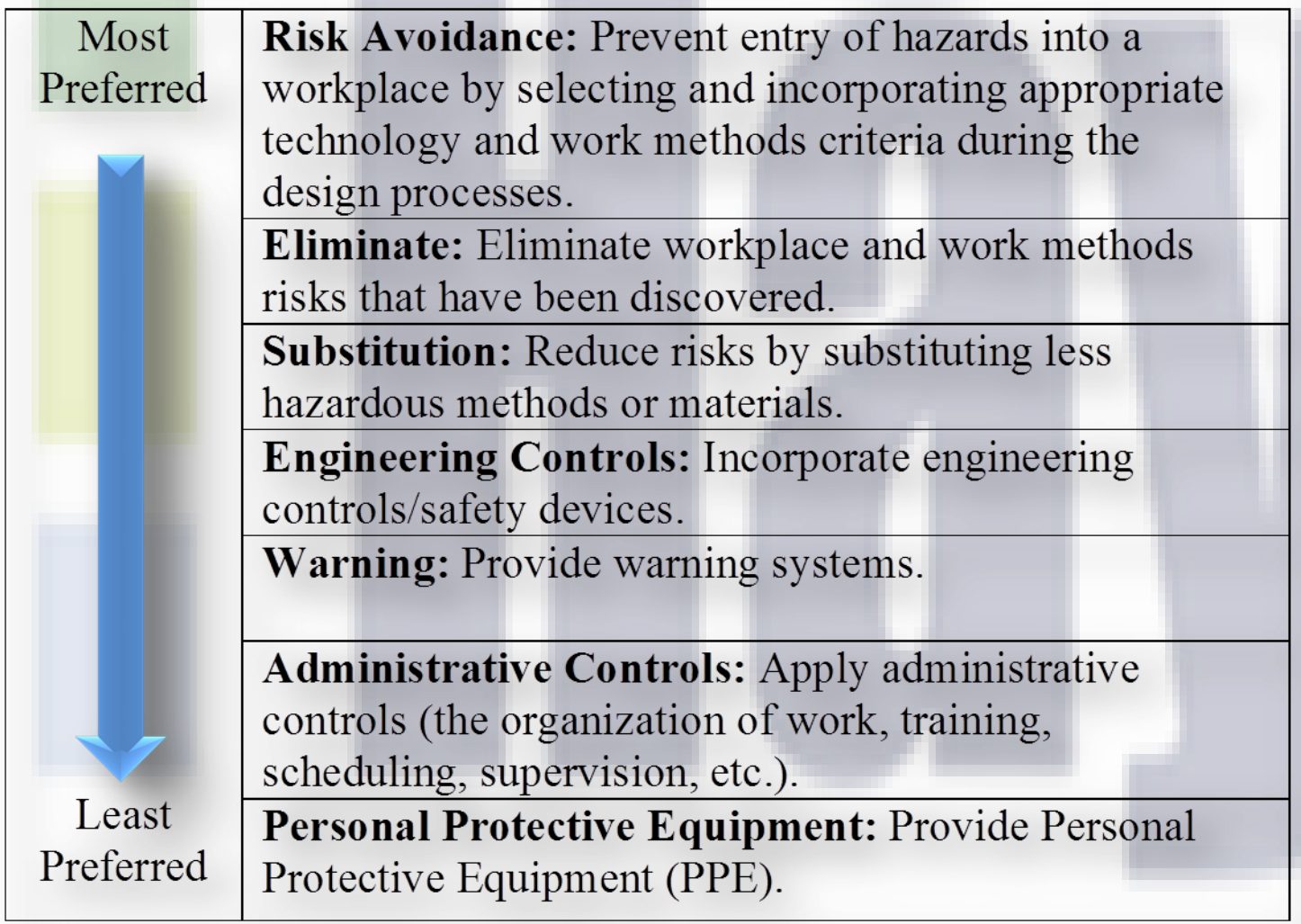
ISO 31000/ANSI/ASSE Z690-2011


Establish Risk Criteria
Establish Context
Assemble Team
Identify Hazards
Analyze Risks
Evaluate Risks
Treat Risks
Document
Monitor / Review
Risk Assessment Process

Hierarchy of Controls

Most Preferred	**Risk Avoidance:** Prevent entry of hazards into a workplace by selecting and incorporating appropriate technology and work methods criteria during the design processes.
	Eliminate: Eliminate workplace and work methods risks that have been discovered.
	Substitution: Reduce risks by substituting less hazardous methods or materials.
	Engineering Controls: Incorporate engineering controls/safety devices.
	Warning: Provide warning systems.
	Administrative Controls: Apply administrative controls (the organization of work, training, scheduling, supervision, etc.).
Least Preferred	**Personal Protective Equipment:** Provide Personal Protective Equipment (PPE).

Hierarchy of Controls



Triggers for Risk Assessment

- Organizational Change
- New Designs or Redesigns
- Change Management
- Procurement
- Third-party interaction
- Non-routine Activities
- High-risk Activities
- Incidents

Selecting Risk Assessment Tools

Consider the following:

- The **Application** (New Design; Existing System; General or Specific Hazards)
- **Level of Detail** Needed
- **Complexity** of the System
- **Size** of the System
- What **Resources** are Available

Selecting Risk Assessment Tools

- ✓As a general rule, the simplest tool or tools that provide sufficient information to make an appropriate risk management decision is advised.
- ✓No single assessment tool is able to meet ‘all’ requirements for all risks.
- ✓Modified tools may be necessary (and even desired)
- ✓Often a combination of tools is necessary.

Selecting Risk Assessment Tools

Fundamental Tools commonly used include:

- JHAs and JRAs
- Preliminary Hazard Analysis
- What-if Analysis
- Failure Mode and Effects Analysis
- Bow Tie Analysis
- Risk Matrix

Job Hazard Analysis

- ✓Used to identify job steps, hazards and controls
- ✓Helpful in job training and incident investigation
- ✓Does not include an ‘assessment of risk’, just identification of hazards and controls

Job Hazard Analysis		
Job: ***Equipment Preparation & Rig Up***		**Date:** ***4-1-15***
Task	**Hazards**	**Controls**
1. Assess location to determine the spotting of equipment	1.a: struck by moving equipment	1.a: Spotters; high visibility vest; controlled access; maintain 25' distance from operation
2. Unhook trailers and rig up gin poles	2.a: hand pinch; 2.b: struck by pole; 2.c: struck by moving equipment	2.a: Grabber hooks with safety latches; hand placement; 2.b: certified cables with tags on poles;2.c: Spotter; High-vis vest
3. Unload iron, valves, separators, plug catchers	3.a: chain sling failure; 3.b: manual handling; 3.c: vehicle backing	3,a: certified & tested slings; visual daily inspection; 3.b: use of mechanical aids; proper lifting; 3.c: spotters; high-vis vest; 360 walk around
4. Set & install plug catcher, hydraulic chokes & half pit	4.a: chain sling failure; 4.b: manual handling; 4.c: backing vehicles	4.a: certified & tested slings; visual daily inspection; 4.b: use of mechanical aids; proper lifting; 4.c: spotters; high-vis vest; 360 walk around
5. Set & install sand separator, bypass, & hook up to frac tank	5.a: chain sling failure; 5.b: pinch points; 5.c: manual handling; 5.d: backing vehicles	5.a: certified & tested slings; visual daily inspection; 5.b: proper hand placement; 5.c: use of mechanical aids; proper lifting; 5.d: spotters; high-vis vest; 360 walk around

Job Risk Assessment

- ✓ Same as JHA but includes a ‘risk assessment’ of each hazard
- ✓ Allow jobs, hazards and controls to be prioritized by ‘risk level’

Job Risk Assessment									
Job: ***Equipment Preparation & Rig Up***					**Assessed by:** ***Smith***	***J. Doe; B.***	**Date:** ***4-1-15***		
			Pre-controls				**Post-controls**		
Task	**Hazard**	**At Risk**	**Initial Severity (IS)**	**Initial Likelihood (IL)**	**Initial Risk (IR)**	**Controls**	**Residual Severity (RS)**	**Residual Likelihood (RL)**	**Residual Risk (RR)**
1. Assess location to determine the spotting of equipment	1.a: struck by moving equipment	Supervisor; equipment; vehicles	**3**	**3**	**13**	1.a: Spotters; high visibility vest; controlled access; maintain 25' distance from operation	**2**	**2**	**5**
2. Unhook trailers and rig up gin poles	2.a: hand pinch; 2.b: struck by pole; 2.c: struck by moving equipment	Ground crew; equipment; vehicles	**4**	**3**	**18**	2.a: Grabber hooks with safety latches; hand placement; 2.b: certified cables with tags on poles;2.c: Spotter; High-vis vest	**3**	**2**	**12**
3. Unload iron, valves, separators, plug catchers	3.a: chain sling failure; 3.b: manual handling; 3.c: vehicle backing	Ground crew; equipment; vehicles	**4**	**3**	**18**	3,a: certified & tested slings; visual daily inspection; 3.b: use of mechanical aids; proper lifting; 3.c: spotters; high-vis vest; 360 walk around	**3**	**2**	**12**
4. Set & install plug catcher, hydraulic chokes & half pit	4.a: chain sling failure; 4.b: manual handling; 4.c: backing vehicles	Ground crew; equipment; vehicles	**4**	**3**	18	4.a: certified & tested slings; visual daily inspection; 4.b: use of mechanical aids; proper lifting; 4.c: spotters; high-vis vest; 360 walk around	3	2	12

Preliminary Hazard Analysis

- ✓An ‘Initial Analysis’ tool
- ✓Used to identify hazards and control measures (current and future/proposed)
- ✓Used for new designs or existing systems
- ✓Allows for risk levels to be prioritized for further assessment and management

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
Dispensing High Hazard Chemical	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	4	3	12	Substitute high hazard chemical with less hazardous product	2	2	4

What-if Analysis

- ✓Team-based brainstorming
- ✓Used to identify and analyze scenarios and hazards
- ✓Typically does not include ‘risk analysis’ (severity and likelihood levels)
- ✓Can be modified to include risk analysis

Structured What-If Technique Analysis

peration/Process: Rail Tank Car Cleaning - Vapor Combustion System

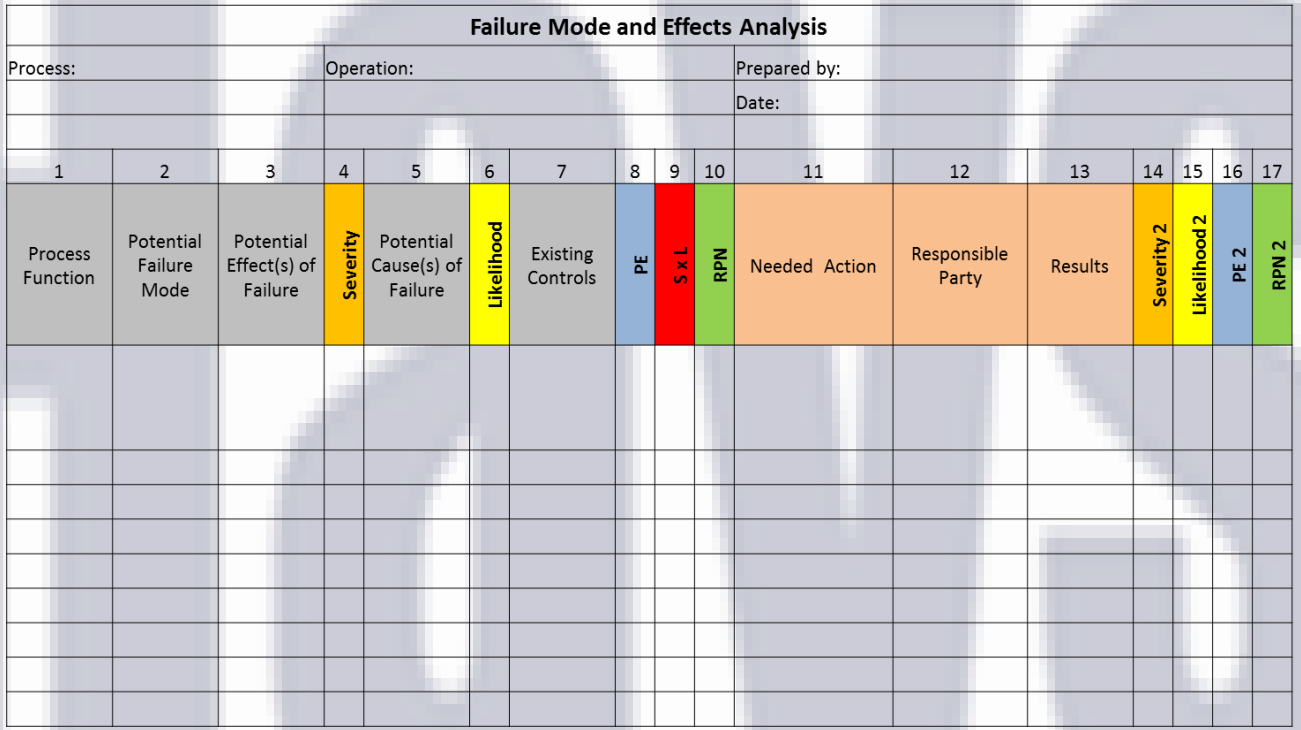
12-17, 2012	Team: Bruce Lyon, Facilitator; Deane H., Fire Protection Specialist; Tom G., Enginee P., Safety & Health; Charles T., Environmental; Don B., Maintenance; Kevin S., Production/Tank Car Cleaning

B. Combustor Start-Up

What-If…	Causes	Consequences	Controls	Recomm
Waste gas valve on degas rack is left open during combustor start-up operation	Human error or omission - waste gas valve is not closed or completely closed.	Fire or explosion; damage to combustor	Operator training in VCS Instructions manual and VCS start-up JSA procedure	B.1.1 Gas open and positions and label B.1.2 Alar valve is n complete start-up.
Steam condensate is not drained from evaporator tank	Human error or omission - tank not completely drained before combustor start-up	Pollution - emissions - incomplete combustion	Operator training in VCS Instructions manual and VCS start-up JSA procedure	B.2.1 Bott on evapo tank with turn mark labeled.

FMEA

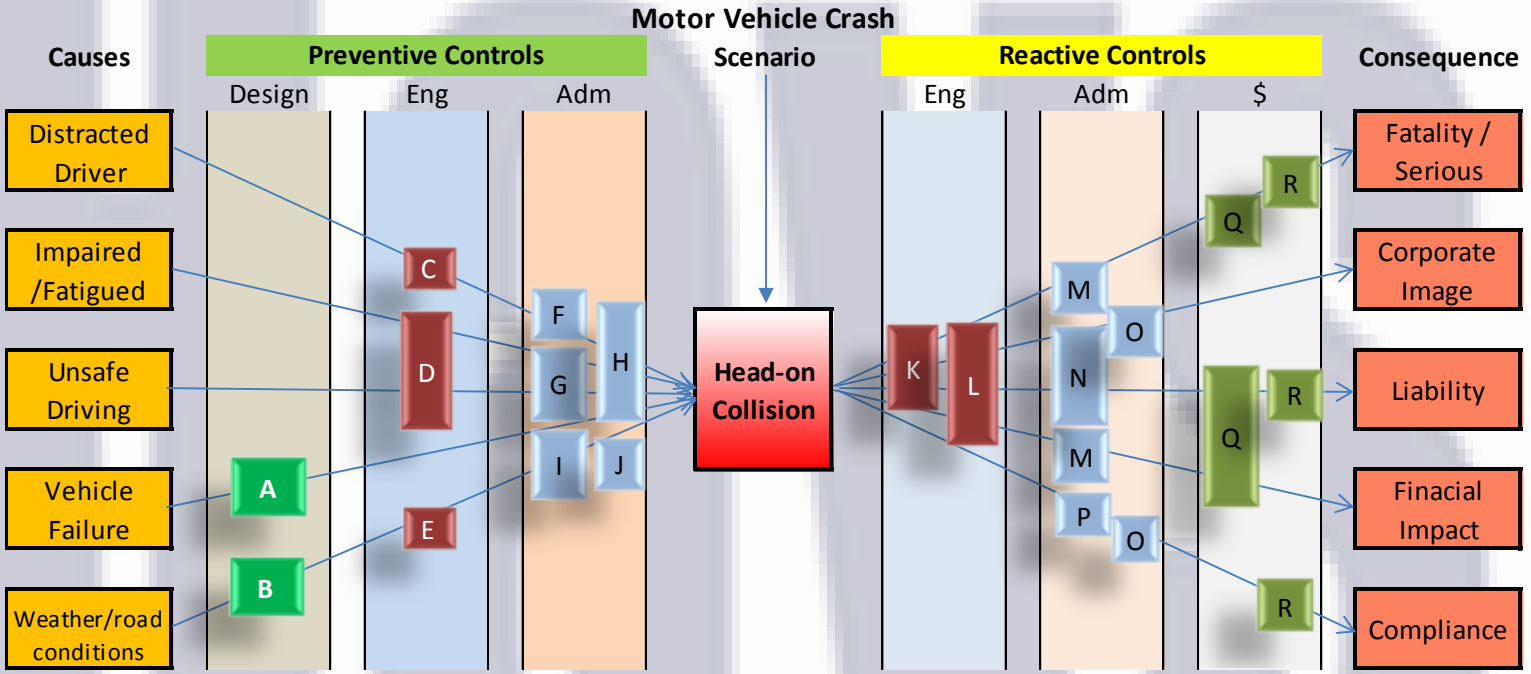
- A method used to identify the ways a system can fail
- Used for new and existing designs, products, processes and systems
- Analyzes failures individually
- FMEA identifies:
  - Potential failure modes
  - Effects of failures
  - The causes of failures
  - How to avoid the failures



Failure Mode and Effects Analysis																
Process:			Operation:							Prepared by:						
										Date:						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Likelihood	Existing Controls	PE	S x L	RPN	Needed Action	Responsible Party	Results	Severity 2	Likelihood 2	PE 2	RPN 2

Bow Tie Analysis

- A combination of a fault tree and event tree analysis
- Used to show risk pathways and control measures - “big picture” view
- Communicate risk exposures and controls
- Attention to both preventive controls and reactive measures
- Typically lacks a risk scoring mechanism



Risk Matrix

- Used to rank risks as part of ‘risk evaluation’
- Provides a consistent method of prioritizing
- Communicates risk to management

Risk Matrix						
Severity	Catastrophic	21	22	23	24	25
	Critical	14	15	18	19	20
	Serious	6	12	13	16	17
	Moderate	4	5	9	10	11
	Minor	1	2	3	7	8
		Improbable	Remote	Occasional	Probable	Frequent
		Likelihood				

Risk Action Levels	
Risk Level	**Action**
Unacceptable	Immediate action required. Operation not permissible, except in rare and extra-ordinary circumstances.
High	Remedial action is to be given high priority.
Moderate	Remedial action is to be taken at appropriate time.
Low	Remedial action is discretionary. Procedures are to be in place to ensure risk level is maintained.

Case Study

1. Concerns from Chemical use
2. Conducted Preliminary Hazard Analysis (PHA) of Winery
3. Proposed High-level Controls

Established Winery's Risk Criteria

Established the Winery's Risk Criteria to be used in the risk assessment

Severity Level	Definition
Catastrophic (4)	Fatalities; Damage to Community, Environment, and Reputation
High (3)	Permanent Disability Injury or Illness; Multiple Injury Events
Moderate (2)	Injury or Illness Requiring Medical Attention
Low (1)	Minor Injury or First Aid Incident

Likelihood Level	Definition
Very Likely (4)	Will happen under right situations; has occurred multiple times
Likely (3)	Likely to happen under right circumstances; has occurred in past
Possible (2)	Can happen in certain situations
Unlikely (1)	Unlikely to happen; remotely possible

	Low (1)	Moderate (2)	High (3)	Catastrophic (4)
Very Likely (4)	4	8	12	16
Likely (3)	3	6	9	12
Possible (2)	2	4	6	8
Unlikely (1)	1	2	3	4

Concern #1 - Pure Liquid Sulfur Dioxide

Used for dosing tanks inside buildings

Filling and Dispensing

Concern #1 - Pure Liquid Sulfur Dioxide

Risks

- Potential for releases during filling and dispensing
- Lethal dose = 100 ppm (Cal-OSHA PEL = 2 ppm) (ACGIH TLV = 0.25 ppm)
- Can cause blindness
- Environmental concerns
- Transporting, dispensing, handling, storage concerns

Concern #1 - Pure Liquid Sulfur Dioxide

Sulfur dioxide (SO_2) gas is heavier than air and can accumulate in closed areas.

The configuration and lack of ventilation in the bottling area presented a significant risk to employees should a SO_2 release occur in the area.

Preliminary Hazard Analysis

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
SO2 Dosing using 100% SO2 liquid	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	**4**	**3**	**12**				
								

Preliminary Hazard Analysis

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
SO2 Dosing using 100% SO2 liquid	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	4	3	12	**Unacceptable FSI Risk**			
								

Proposed Control – Substitute with Less Hazardous Product

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
SO2 Dosing using 100% SO2 liquid	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	4	3	12	**Substitute** 100% SO_2 with 6% liquid SO_2 and $K_2S_2O_5$ (potassium meta-bisulfite) effervescent tables, granular, powder	**2**	**2**	**4**
 								

Proposed Control – Substitute with Less Hazardous Product

67% risk reduction

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
SO2 Dosing using 100% SO2 liquid	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	4	3	12	**Substitute** 100% SO_2 with 6% liquid SO_2 and $K_2S_2O_5$ (potassium meta-bisulfite) effervescent tables, granular, powder	**2**	**2**	**4**
 								

Concern #2 –DMDC Dosing

- Dimethyl Dicarbonate (DMDC) - used to prevent spoilage
- DMDC inhibits yeast with half-life of 3 hours which converts to CO2 and methanol
- Highly specialized metering equipment and training operators

Concern #2 –DMDC Dosing

- Metering equipment located in the bottling area
- Bottling Area had limited ventilation and limited means of escape
- Exposure ceiling limit is 0.04 ppm
- Releases have occurred due to operator error and equipment failure

Preliminary Hazard Analysis

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
DMDC metering equipment in bottling area	Health risk to bottling employees from leak or release in area; 0.4 ppm exposure ceiling limit	4	3	12	**Unacceptable FSI Risk**			

Preliminary Hazard Analysis

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
DMDC metering equipment in bottling area	Health risk to bottling employees from leak or release in area; 0.4 ppm exposure ceiling limit	**4**	**3**	**12**	Eliminate exposure - relocate DMDC unit outside building (connected with hose) with open ventilation away from bottling area; continue to follow safety protocols and PPE for operator.	**3**	**1**	**3**

Preliminary Hazard Analysis

75% risk reduction

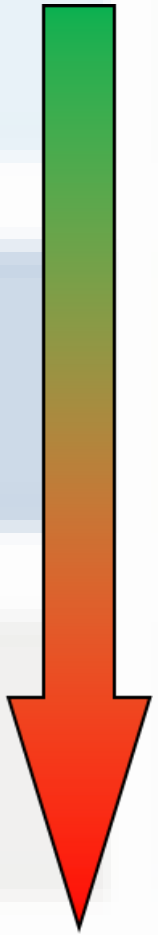
Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
DMDC metering equipment in bottling area	Health risk to bottling employees from leak or release in area; 0.4 ppm exposure ceiling limit	4	3	12	**Eliminate** exposure - relocate DMDC unit outside building (connected with hose) with open ventilation away from bottling area; continue to follow safety protocols and PPE for operator.	3	1	3

As a Result ➡ Eliminated two FSI Risks

Task	Hazard	Current Severity	Current Likelihood	Current Risk Level	Recommended Controls	Future Severity	Future Likelihood	Future Risk Level
SO2 Dosing using 100% SO2 liquid	Health risk from leak or release; 2 ppm PEL; 100 ppm lethal dose; Heavier than air. EPA regulated product.	4	3	12	**Substitute** 100% SO_2 with 6% liquid SO_2 and $K_2S_2O_5$ (potassium meta-bisulfite) effervescent tables, granular, powder	**2**	**2**	**4**
DMDC metering equipment in bottling area	Health risk to bottling employees from leak or release in area; 0.4 ppm exposure ceiling limit	4	3	12	**Eliminate** exposure - relocate DMDC unit outside building (connected with hose) with open ventilation away from bottling area; continue to follow safety protocols and PPE for operator.	**3**	**1**	**3**

ANSI B11.0 – Hazard Control Hierarchy

Most Preferred



Least Preferred

Risk Reduction Measures	Examples	Influence on Risk Factors	Classification
Elimination or Substitution	• Eliminate pinch points (increase clearance) • Intrinsically safe (energy containment) • Automated material handling (robots, conveyors, etc.) • Redesign the process to eliminate or reduce human interaction • Reduced energy • Substitute less hazardous chemicals	• Impact on overall risk (elimination) by affecting severity and probability of harm • May affect severity of harm, frequency of exposure to the hazard under consideration, and/or the possibility of avoiding or limiting harm depending on which method of substitution is applied.	Design Out
Guards, Safeguarding Devices, and Complimentary Measures	• Barriers • Interlocks • Presence sensing devices (light curtains, safety mats, area scanners, etc.) • Two hand control and two-hand trip devices	• Greatest impact on the probability of harm (Occurrence of hazardous events under certain circumstance) • Minimal if any impact on severity of harm	Engineering Controls
Awareness Devices	• Lights, beacons, and strobes • Computer warnings • Signs and labels • Beepers, horns, and sirens	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	Administrative Controls
Training and Procedures	• Safe work procedures • Safety equipment inspections • Training • Lockout / Tagout / Verify	• Potential impact on the probability of harm (avoidance and/or exposure) • No impact on severity of harm	
Personal Protective Equipment (PPE)	• Safety glasses and face shields • Ear plugs • Gloves • Protective footwear • Respirators	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	

PHA Results

Implementing ‘higher level’ controls including ‘substitution’ and ‘elimination’ resulted in the following benefits:

- Removed two Fatal or Serious Incident (FSI) level risks
- A risk reduction of 66% for SO2 exposure to employees and community
- A reduction in risk level of 75% for DMDC exposure risk
- Improved employee morale
- Eliminated EPA reporting requirements for SO2
- Reasonably low costs for $K_2S_2O_5$ effervescent tables and ease of use
- Low costs to relocate and shelter DMDC metering machine outside

Using a Series of Risk Assessment Tools

Hazard Analysis and Risk Assessment

Hazard ID:

Hazard Description:

Exposure Interval: | Activity/Process Phase:

Initial Risk Assessment

Hazard Targets:	Severity	Probability	Risk Code
Personnel			
Equipment			
Downtime			
Environment			
Product			

Additional Countermeasures:

Post-countermeasures Risk Assessment

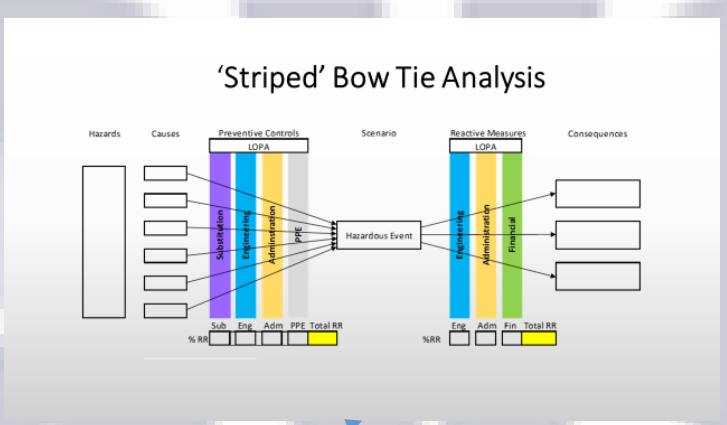
Hazard Targets:	Severity	Probability	Risk Code
Personnel			
Equipment			
Downtime			
Environment			
Product			

Countermeasure codes:
(D) Design alternation (E) Engineering (P) Process
(S) Safety Device (W) Warning (T) Training

Comments:

Prepared by: | Reviewed by: | Approved by:

Adapted from Advanced Safety Management: Focusing on Z10 and Serious Injury Prevention by Fred Manuele



Failure Mode and Effects Analysis

Process: | Operation: | Prepared by:
Date:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Existing Controls	PE	Sev + Occ	RPN	Needed Action	Responsible Party	Results	Severity 2	Occurence 2	PE 2	RPN 2

Risk Matrix

Severity					
Catastrophic	21	22	23	24	25
Critical	14	15	18	19	20
Serious	6	12	13	16	17
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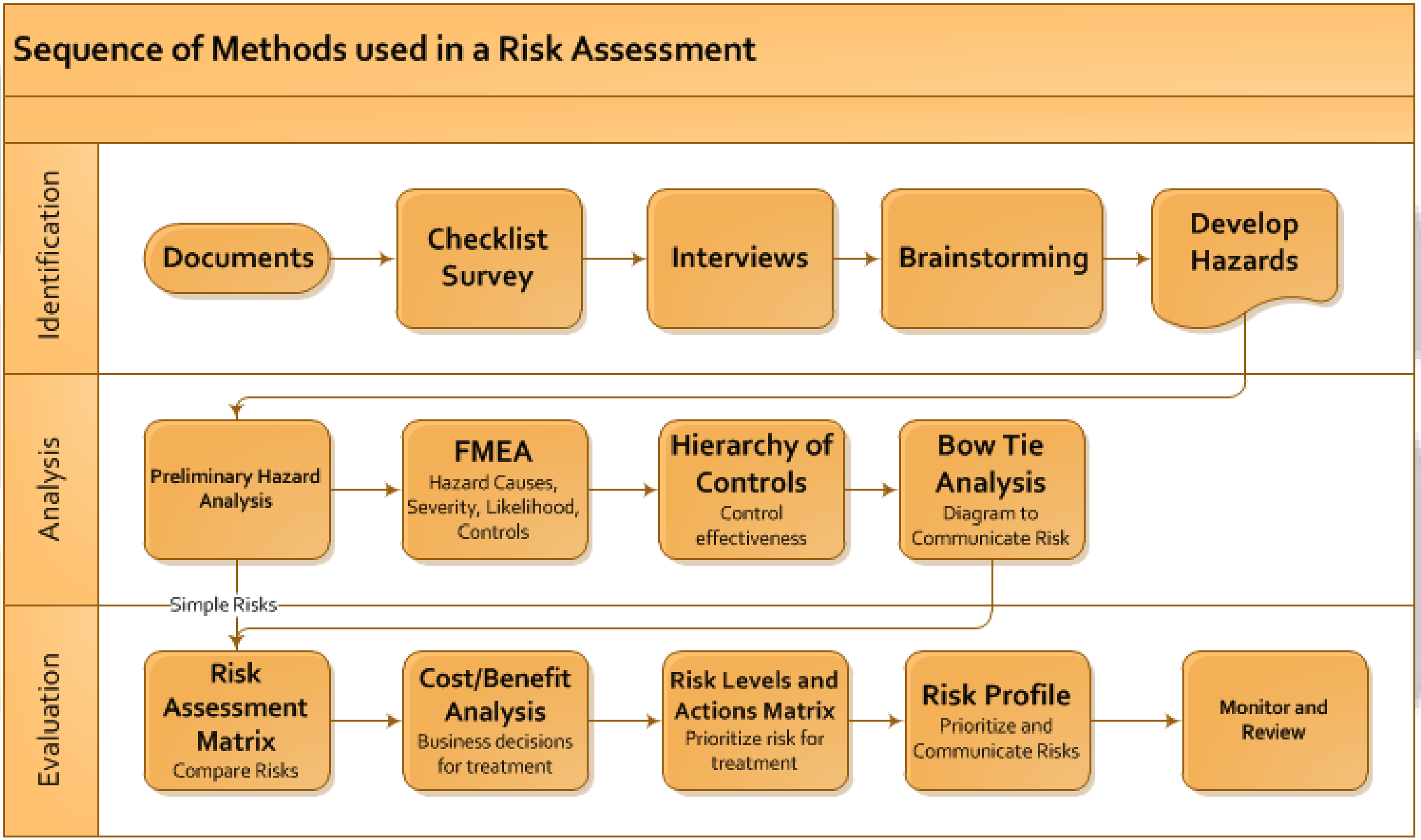
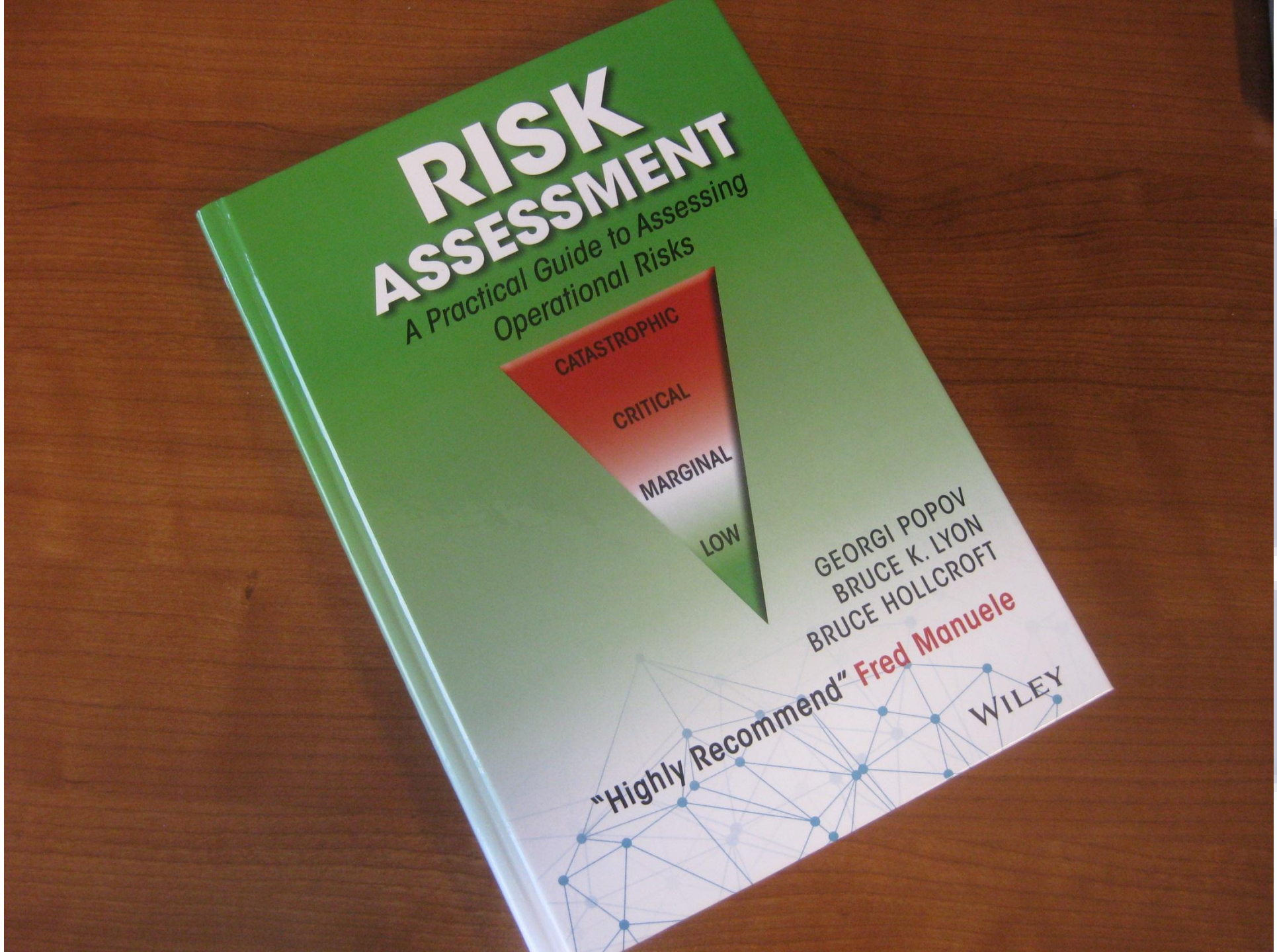
	Improbable	Remote	Occasional	Probable	Frequent
	Likelihood				


Sequence of Methods used in a Risk Assessment
Identification
Analysis
Evaluation
Documents
Checklist Survey
Interviews
Brainstorming
Develop Hazards
Preliminary Hazard Analysis
FMEA
Hazard Causes, Severity, Likelihood, Controls
Hierarchy of Controls
Control effectiveness
Bow Tie Analysis
Diagram to Communicate Risk
Simple Risks
Risk Assessment Matrix
Compare Risks
Cost/Benefit Analysis
Business decisions for treatment
Risk Levels and Actions Matrix
Prioritize risk for treatment
Risk Profile
Prioritize and Communicate Risks
Monitor and Review


RISK
ASSESSMENT
A Practical Guide to Assessing Operational Risks
CATASTROPHIC
CRITICAL
MARGINAL
LOW
GEORGI POPOV
BRUCE K. LYON
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